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Advanced oxidation process associated with membrane separation for the treatment of sanitary landfill leachate

L.M. Diniz, L.H. Andrade, T.L. Manssula, E.P. Rocha, M.C.S. Amaral, L.C. Lange, M. Machado*
Federal University of Minas Gerais, Brazil

INTRODUCTION

In many countries the most common form of disposal of municipal solid waste is landfill, due to the economic advantages offered. However, this system presents problems such as the generation of leachate and biogas derived from the waste decomposition. According to Renou et al. (2008), leachate can be defined as the liquid from the percolation of rainwater on the waste, the water produced from the degradation of organic matter and the water inherent of the waste. This effluent can have a high organic matter (biodegradable and refractory), presenting in its constitution humic substances, nitrogen, heavy metals, organochlorines and inorganic salts and, therefore has a high pollution potential (GOTVAJN et al., 2011).

Due to the complexity and variety of this effluent, choosing the optimal method of treatment is still a challenge (Renou et al., 2008). For a long time, the traditional biological treatments and classical physicochemical methods were considered the most appropriate technologies for treating effluents with special characteristics, such as leachate from landfills. However, the existence of increasingly restrictive standards regarding the discharge of effluent on water bodies and the aging of landfills cause the conventional treatments not to provide adequate removal efficiencies anymore, resulting in the search for alternative technologies (Renou et al., 2008; Ziyang et al., 2009). In this scenario, technologies such as the advanced oxidation processes (AOP) and membrane separation processes (MSP) arise as promising alternatives for the treatment of leachate.

Thus, the aim of this study was to evaluate the performance of two routes for leachate treatment, consisting of AOP associated with MSP microfiltration and nanofiltration.

METHODS

Two different routes for the treatment of leachate from the landfill of the city of Belo Horizonte, Brazil, were evaluated.

In the first route, the raw leachate was treated by AOP using Fenton reagent (AOP-Fenton), after which it was sent to a microfiltration unit (MF-1) in order to remove the sludge formed in the oxidation process. Finally, the permeate of MF was nanofiltrated (NF-1), generating the final treated effluent. In the second route, the raw leachate was initially microfiltered (MF1-2), being separated into two parts: permeate and concentrate. The concentrate underwent the AOP-Fenton process and subsequently, a second unit MF to sludge removal (MF2-2). The permeates from the two MFs were mixed and sent to the NF (NF-2). The permeate of the NF-2

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consisted on treated effluent, and the concentrate returned to the stage of AOP-Fenton. The second route aimed less waste generation (concentrates from the MF and NF units) and less reagents consumption in AOP-Fenton process, since only concentrates from the MF1-2 and NF-2 have gone through this stage and not all leachate flow, as in the first route.

Figure 1 shows a schematic of the two routes evaluated.

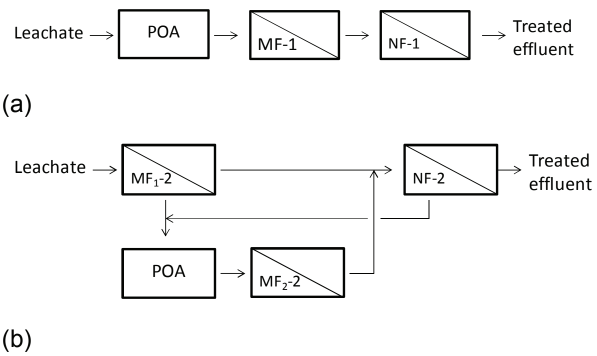


Figure 1: Scheme of a route 1 (a) and 2 (b) for treatment of leachate.

The Fenton reaction lasted 28 minutes and was performed using as reagents ferrous sulfate heptahydrate and hydrogen peroxide 30% in the following proportions: 1.7 g H2O2 / g COD raw leached and 1g FeSO4.7H2O / 5.3 g H2O2 (MORAVIA et al ., 2011). A recovery rate of the 60% was determined for all stages with membranes. The routes were evaluated and compared in terms of removal efficiency of COD, color, total solids, ammonia-nitrogen, phosphorus and chlorine (APHA, 2005) and performance of the filtration steps.

RESULTS

The Table 1 shows the results of the routes 1 and 2 in terms of removal efficiency of pollutants.

Table 1: Values of the main physicochemical parameters for the raw leachate and the treated effluent and global removal efficiencies for routes 1 and 2

Parameter	Route 1			Route 2		
	Raw Leachate	Treated Leachate	Removal Efficiency	Raw Leachate	Treated Leachate	Removal Efficiency
COD (mg/L)	2.848,4	106,0	96%	3.702,5	211,2	94%
Total solids	10.274	2.942	71%	10.493	1.612	85%

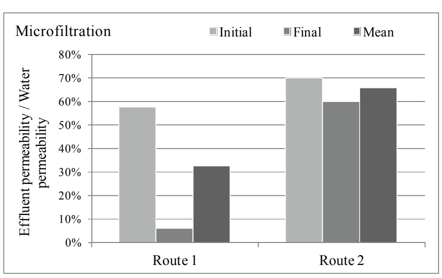
(mg/L)						
Color (uH)	1.691,0	10,8	99%	1.688,9	14,7	99%
$N\text{-}NH_3$ (mg/L)	1319	274	79%	1567	461	71%
Phosphorus (mg/L)	32	3	92%	32	3,3	90%
Chlorides (mg/L)	2799,1	1066,3	62%	2699,2	622,0	77%

It was observed high removal efficiencies of COD, color and phosphorus, and also significant removal of ammonia, total solids and chlorides. For most parameters, no significant differences were observed between the overall efficiencies of routes 1 and 2.

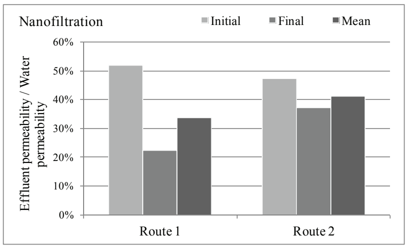
About 72% of the COD from initial raw leachate was removed in AOP-Fenton step, which shows that the oxidation phase is essential for a good performance of the process. Nanofiltration showed removal efficiencies of COD, total solids and color of 75-87%, 82-85% and 89-97% respectively for the two routes evaluated. Thus, it emphasizes the importance of this step for polishing the effluent and obtaining treated leachate with high quality.

Despite satisfactory removal of solids by the role process, it can be noticed that the concentration thereof in the final treated effluent also has relatively high values. This is justified by the fact that the solids concentration increased after AOP-Fenton, which is due to the addition of the iron sulphate, and by the inability of NF to retain all dissolved solids from the effluent.

Figure 2 shows the relationship between the initial, final, and medium permeabilities with effluent and the permeabilities with pure water of the cleaned membranes obtained during the filtration steps of the routes 1and 2.



(a)



(b)

Figure 2: Performance of processes (a) microfiltration of sludge generated in step AOP-Fenton and (b) nanofiltration in terms of initial permeability, middle and end with effluent divided by the permeability of water with membrane clean.

It is observed that the route 2 performed better than the route 1 in terms of membrane fouling. Both for MF and for the NF, route 2 had higher values of permeability, indicating smaller fouling.

CONCLUSION

Based on the data presented, we conclude that the second route is more suitable for the treatment of landfill leachate. It presented removal efficiencies quite satisfactory for all parameters monitored, and lower fouling on the membranes, resulting in lower operating costs regarding cleaning the membranes and replacement of modules.

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